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Abstract

Use of Response Matrix Method for Multilayer Shield Design

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This paper represents a method for computing the transmission and reflection of gamma-rays in multilayer slab shields. The method is based on the fact that the transmission and reflection behaviour of radiations in a barrier can be expressed by an operator, a matrix in this case.

Peebles and Plesset have pointed out the applicability of matrix method to the shield calculation. The operators were evaluated for elementary slabs of iron and lead, in which photons suffered more than three collisions were ignored. Yarmush, Zell and Aronson have developed it into the transmission matrix method. The matrices are deduced from elementary matrices which depend on the material but not on the thickness. In evaluating elementary matrices the formula for once collision of radiations are used.

The response matrix method described in this paper is defferent from the transmission matrix method in three points. The first of these, the elementary response matrices are computed by the Monte Carlo method and by the direct integration of the transport equations, which are based on less assumptions than the other matrix methods are based on. The second, in this method the angular distributions of gamma-rays are divided into direction groups up to seven, whereas in the transmission matrix method the angular distributions are expanded as linear combination of basic functions of angle. The third, the response matrices of each material are prepared for two different thicknesses, thin and thick. Each response matrix is calculated for the barrier of that thickness directly and is not deduced from matrices of a elementary slab, i.e., of a extremely thin slab. This avoids accumlations of the errors in the deep penetration calculations.

The number flux, energy flux or energy current of gamma-rays is divided into energy groups up to eight and also into seven directional groups. The response matrices for water, aluminum, iron and lead have been prepared.

The energy and the angular distribution of transmitted and reflected photons in the multilayer shield can be calculated by operating the response matrices of each elementary slab to the incoming distributions successibely.

Although there are differences between the response matrix method and the other matrix methods in the expression of matrix and the way of calculating the matrices as mentioned before, the advantages of the response matrix method as well as the other matrix methods are as follows.

1) The effect of the multilayer arrangement is treated correctly.
2) Computation time is short. Though the evaluation of elementary response matrices requires significant machine time, it does not need to compute for the same material again.
3) The computation offers many informations.
4) It is suitable to deep penetration calculations.

Sample calculations are compared with the results of the direct integration of the transport equation and those of other Monte Carlo calculations.